S23
鑫海锦江大酒店天津厅

医学图像与人工智能
Medical Imaging and Artificial Intelligence

主席：夏　灵

2020 年 11 月 21 日　星期六　13:30-17:50		
特邀报告第一场 主持人：夏灵、邬霞		
时间	**演讲者姓名和单位**	**演讲题目**
13:30-13:50	**张道强**　南京航空航天大学计算机科学与技术学院	脑影像智能分析与脑疾病早期诊断
13:50-14:10	**冯衍秋**　南方医科大学生物医学工程学院	腰椎定量磁化率成像及其在骨质疏松评估中的应用
14:10-14:30	**杨　健**　北京理工大学光电学院	超声引导穿刺手术导航机器人研发
14:30-14:50	**许　燕**　北京航空航天大学生物与医学工程学院	弱监督和无监督学习在医学及病理图像分析上的探索
14:50-15:10	**何晖光**　中国科学院自动化研究所	基于“What”和“Where”的视觉神经信息编码方法
15:10-15:30	**宋小磊**　清华大学生物医学工程系	CEST-MRI 的 Z 谱再挖掘：从线型拟合到多参数方法
15:30-15:50	茶歇	
特邀报告第二场 主持人：厉力华、陈阳		
15:50-16:10	**张　寒**　张江实验室脑与智能科技研究院	基于高阶脑网络建模和机器学习的脑疾病个体化诊断研究
16:10-16:30	**王珊珊**　中国科学院深圳先进技术研究院	深度学习多对比度快速磁共振成像与分析
16:30-16:50	**朱闻韬**　之江实验室网络健康大数据研究中心	无 CT 辐射伴随的 PET 延迟成像
16:50-17:10	**黄炳升**　深圳大学生物医学工程学院	基于深度语义分割特征的影像组学方法
17:10-17:30	**徐　军**　南京信息工程大学信息与控制学院	计算病理与组织形态学定量分析：它们在非癌症病理中的研究价值
17:30-17:50	**倪　东**　深圳大学生物医学工程学院	强化学习与智能超声

主席：夏　灵

Email: xialing@zju.edu.cn

浙江大学教授兼生物医学工程研究所所长，博导，中国生物医学工程学会理事、医学图像信息与控制分会副主任委员，教育部新世纪优秀人才支持计划入选者。研究方向为心脏建模仿真，心电功能成像，磁共振成像关键技术。

张道强

Email: dqzhang@nuaa.edu.cn

南京航空航天大学计算机科学与技术学院、人工智能学院教授，副院长，国际模式识别协会会士（IAPR Fellow），国家科技部中青年科技领军人才，“万人计划”青年拔尖人才，国家优秀青年基金获得者。

杨　健

Email: jyang@bit.edu.cn

北京理工大学光电学院教授，博士生导师。长期从事医学图像处理和手术导航等方面的研究工作，以第一 / 通讯在 IEEE T-MI、IEEE T-IP 等国际著名期刊上发表 SCI 论文 70 余篇。

倪　东

Email: nidong@szu.edu.cn

深圳大学医学部生物医学工程学院副院长，人工智能医疗影像国际顶级会议 MICCAI 理事会成员，国家重点研发计划首席科学家。专注于智能医学超声研究，成果实施了大规模的临床应用及产业转化，获得了深圳市科技进步奖一等奖。

何晖光

Email: huiguang.he@ia.ac.cn

中国科学院自动化研究所研究员，博士生导师，中国科学院大学岗位教授，福建省“闽江学者”讲座教授。医学图像计算青年研讨会 MICS 在线首任主席，建国七十周年纪念章获得者。

张　寒

Email: hanzhang.bit@gmail.com

曾任北卡罗莱纳大学教堂山分校助理教授，2020 年 9 月起任张江实验室脑与智能科技研究院研究员，PI，脑疾病与智能计算研究组研究组长。

朱闻韬

Email: wentao.zhu@zhejianglab.com

之江实验室网络健康大数据研究中心副主任，浙江省千人计划入选者。

冯衍秋

Email:foree@163.com

南方医科大学教授，主要研究快速精准可靠的定量磁共振成像方法，以反映生物组织疾病发生发展过程中结构、成分、功能、与代谢等信息的变化，服务于疾病的诊断与治疗。

徐　军

Email: xujunus@gmail.com

南京信息工程大学教授，博士生导师。主要研究领域为计算病理、医学图像计算等。

许　燕

Email: xuyan@buaa.edu.cn

北京航空航天大学生物与医学工程学院长聘副教授，硕士导师。微软亚洲研究院访问研究员。获得国家自然科学基金优秀青年基金，北京市青年英才和微软亚洲研究院铸星计划。中国生物医学工程学院人工智能分会青年委员；中国睡眠协会老年分会青年委员。

宋小磊

Email: songxl@tsinghua.edu.cn

清华大学生物医学工程系副教授，国家海外高层次人次引进计划青年项目入选者。

王珊珊

Email: ss.wang@siat.ac.cn;

中科院深圳先进技术研究院副研究员，博士生导师，Gordon plenary lecturer, OCSMRM 杰出研究奖获得者及 Biomedical signal processing and control, IEEE reviews in biomedical engineering, Magnetic resonance in medicine 编委。

黄炳升

Email: huangb@szu.edu.cn

深圳大学医学部生物医学工程学院副教授主要从事 CT、PET 和 MRI 等医学图像的智能处理在癌症和大脑疾病中的应用及转化研究。主持十余项国家级、省级和市级科研项目，经费总计近 1000 万元人民币；发表 SCI 论文 50 余篇，申请专利 20 余项。

脑影像智能分析与脑疾病早期诊断

张道强　南京航空航天大学
Email: dqzhang@nuaa.edu.cn

近年来，“脑科学计划”吸引了各国政府和公众的广泛关注。脑影像技术是研究脑科学的重要工具之一，然而由于脑影像数据所固有的高维度、多模态、异构和时变等特性，对其进行快速有效分析是当前研究的关键问题之一。在本报告中，我们将首先简要介绍脑影像分析的基本方法，然后重点介绍我们近几年在基于机器学习的脑影像／脑网络智能分析方面的相关工作，并介绍其在脑疾病早期诊断、影像遗传学、脑认知与脑解码中的应用。

Intelligent Analysis of Brain Imaging for Early Diagnosis of Brain Diseases

Daoqiang Zhang
Nanjing University of Aeronautics and Astronautics

In recent years, the brain research projects have received considerable public and governmental attentions worldwide. Brain imaging technique is an important tool for brain science research. However, due to the high-dimensional, multi-modality, heterogenous, and time-variant characteristics of brain images, it is very challenging to develop both efficient and effective methods for brain image analysis. In this talk, I will introduce our recent works on intelligent methods of brain imaging, based on machine learning techniques. Specifically, this talk will cover the topics including multi-modal brain image fusion and classification, image genomic association analysis, functional alignment and brain network analysis, as well as their applications in early diagnosis of brain disease and brain decoding.

腰椎定量磁化率成像及其在骨质疏松评估中的应用

冯衍秋
南方医科大学
Email: foree@smu.edu.cn

定量磁化率成像（QSM）能够无创获得生物组织磁化率的空间分布。骨质疏松的典型表现是含钙骨矿物质的流失，钙是抗磁性的，其不断流失导致磁化率上升，因此 QSM 在骨质疏松评估方面非常有潜力。由于骨 T2* 很短，为了获得高信噪比图像，我们利用超短回波时间采集成像数据；为了避免脂肪信号干扰，我们提出采集水脂同相时刻的信号，实现了腰椎 QSM 成像。在此基础上，我们开展了腰椎 QSM 用于骨质疏松评估的可行性研究，发现腰椎磁化率值与定量 CT 值高度相关，同时可重复性高，并且能准确区分骨质疏松与非骨质疏松患者。超短回波时间序列数据采集时间较长，我们进一步提出了基于传统笛卡尔采样的双 TR 腰椎 QSM 方法，成像时间缩短为 5 分钟且能同时定量 QSM 和脂肪分数。

Quantitative Susceptibility Mapping of Lumbar Vertebra with Application to Osteoporosis

Yanqiu Feng
Southern Medical University

Quantitative susceptibility mapping (QSM) can invasively obtain the spatial distribution of magnetic susceptibility in biological tissues, and it is widely used in measuring tissue contents such as iron and calcification. Osteoporosis is a systemic bone disease that is characterized by the decrease of bone mineral density (BMD). Calcium in the bone mineral is diamagnetic, and it gradual loss will result in the increase of susceptibility. Thus, QSM is promising for the assessment of osteoporosis. To address the rapid signal decay caused by short T2* in the bone, we proposed to use the ultra-short echo time (UTE) sequence to acquire QSM data with sufficient signal-to-noise ratios. In addition, we acquired lumbar QSM data at the echo time when the water and fat are in phase to remove the impact from fat on field mapping. Furthermore, we investigated the efficacy of quantitative susceptibility mapping (QSM) in the assessment of osteoporosis for postmenopausal women. The results showed that the lumbar QSM value was highly correlated with QCT value. In addition, QSM in the lumbar vertebra is a reliable and reproducible technique for evaluating bone mineral density. Lumbar QSM is feasible in the assessment of osteoporosis for postmenopausal women. We also found that the combination of vertebral susceptibility and fat content further improved the evaluation postmenopausal osteoporosis, compared with individual measures. The UTE-based lumbar QSM required a long acquisition time. For rapid lumbar QSM that can be used in clinical practice, we recently developed an in-phase (IP) echo initialization of R2*-IDEAL for QSM in the spinal vertebrae. The method successfully obtained lumbar QSM in 5 minutes with the simultaneous quantification of fat and susceptibility.

超声引导穿刺手术导航机器人研发

杨　健
北京理工大学
Email: jyang@bit.edu.cn

超声引导下经皮穿刺手术是临床上腹腔肿瘤检测、治疗的重要手段。然而，由于超声影像分辨率低、腹部组织受呼吸运动影响发生形变及过度依赖医生经验等问题导致穿刺针无法准确到达病灶位置处，从而影响检测、治疗的精度。针对以上问题，本研究团队在计算机辅助诊疗精准导航方向围绕核心问题进行了深入研究，提出了器官血管分割建模、超声影像三维重建、呼吸运动补偿以及多模态图像配准融合等医学影像分析算法，在穿刺手术术前阶段实现了重要组织轮廓、位置的精确提取，在术中阶段实现了对穿刺针行进过程的实时引导，在术后阶段实现了治疗效果的综合评估。同时，结合机器人控制理论，成功研制了超声引导穿刺手术导航机器人系统，通过机械臂末端夹持穿刺针进行穿刺，依据医学影像分析算法处理结果，自动避开重要组织，快速准确地到达病灶位置处，使得安全可控机器人自动穿刺成为了可能。

Research and Development of Ultrasound-guided Puncture Surgery Navigation Robot

Jian Yang
Beijing Institute of Technology

Ultrasound-guided percutaneous puncture surgery is an important method for abdominal tumor detection and treatment. However, due to the low resolution of ultrasound images, the respiration-induced motion of the abdominal tissues, and the excessive reliance on the doctor's experience, the puncture needle could not accurately reach the location of the lesion, which affects the accuracy of detection and treatment. To tackle the above problems, the research team conducted in-depth research on the core issues in the direction of computer-aided diagnosis and precision navigation, and proposed medical image analysis algorithms such as the tissues segmentation, three-dimensional reconstruction of the ultrasound slices, respiratory motion compensation, and multi-modal image fusion. The algorithm realizes the precise extraction of important tissue contour and position in the preoperative stage, real-time guidance of the puncture needle during the intraoperative stage, and comprehensive evaluation of the treatment effect in the postoperative stage. At the same time, combined with the robot control theory, the research team successfully developed an ultrasound-guided puncture surgery navigation robot system. The puncture needle is held by the end of the robotic arm to perform puncture. According to the results of medical image analysis algorithms, the puncture needle automatically avoids important tissues and quickly and accurately reaches the location of the lesion. The ultrasound-guided puncture surgery navigation robot system makes it possible for safe and controllable robots to automatically puncture.

计算病理与组织形态学定量分析：它们在非癌症病理中的研究价值

徐　军
南京信息工程大学
Email: xujung@gmail.com

近年来，由于数字病理与人工智能等技术的推动，计算病理在癌症病理的研究得到了很大的关注。计算病理在非癌症病理领域也蕴含着巨大的研究价值。本报告将介绍我们正在进行的非癌症病理：小鼠睾丸病理自动分期系统的工作。由于哺乳动物睾丸结构和精子发育过程的相似性，研究人类的精子发育过程以及不育症等疾病，通常以小鼠睾丸为模型。小鼠睾丸中精子发育被划分为 12 个发育阶段，对 12 个发育阶段的准确分期是研究哺乳动物精子发育的基础。由于睾丸中曲细生精管中精子的发育是一个连续的过程，病理医生肉眼区分 12 个发育阶段通常是根据 H&E 染色切片中不同类型生殖细胞的在不同发育阶段组合和配比，以及所在的不同的生精管区域等组织形态学特征。准确区分 12 个发育阶段需要病理医生经过长期的训练和经验积累，某些阶段比如 VI-VIII 期区分非常困难，需要借助 PAS 染色才能更好地区分。目前只有少数的病理医生能够准确区分 I-XII 个发育阶段。我们首次根据常规 H&E 切片的组织形态学定量分析，提出了一个自动分期模型，包括了睾丸病理切片横断面中生精管区域的自动分割，多类生殖细胞的识别和分割、生精管中多个病理同心层区域的分割，接下来综合生殖细胞层次和同心层组织层次的特征，构建了 I-XII 阶段的自动分期系统。报告中我将详细介绍这个分期系统。

Computational Pathology and Histomorphological Analysis for Non-cancer Pathology

Jun Xu
Nanjing University of Information Science and Technology

Computational pathology is an integration of digital pathology and artificial intelligence technology. In recent years, due to the rapid development of digital pathology and artificial intelligence, the research of computational pathology in cancer histology has received great attention. Computational pathology also has great research value in the field of non-cancer histology. In this talk, I will introduce our ongoing study on non-cancer pathology: computerized spermatogenesis staging of mouse testis sections via quantitative histomorphological analysis. Due to the similarity between mammalian testis structure and sperm development process, the studies on human sperm development and infertility usually takes mouse testis as a model. Sperm development in the mouse testis is divided into 12 developmental stages. The accurate staging of the 12 developmental stages is the basis for the study of mammalian sperm development. Since the development of sperm in the seminiferous tubules in the testis is a continuous process, the pathologist visually distinguishes the 12 developmental stages usually based on the combination of different types of germ cells in the H&E stained sections. Accurately distinguishing the 12 developmental stages requires long-term training and experience accumulation. Certain stages such as VI-VIII stages are very difficult to distinguish, and PAS staining is needed to better distinguish. Based on the quantitative analysis of histomorphology of regular H&E slices, we have developed a Computerized Staging system of Spermatogenesis (CSS) for mouse testis sections through learning of an expert with decades of experience in mouse testis staging. In this talk, I will give a detailed discussion on the CSS system.

强化学习与智能超声

倪　东
深圳大学
Email: nidong@szu.edu.cn

用户差异大、标准化程度低是医学超声诊断面临的主要挑战。深圳大学 MUSIC（Medical UltraSound Image Computing，医学超声图像计算，www.music-bme.net）实验室基于图像分析、人工智能及机器人技术，长期致力于超声诊断的标准化、定量化和智能化研究。报告将详细介绍 MUSIC 实验室基于智能强化决策，开展的三维超声标准切面定位、超声多模态图像分析及标记点定位等系列研究，揭示利用前沿的人工智能方法解决超声诊断所面临挑战的研究思路。

Reinforcement Learning and Intelligent Ultrasound

Dong Ni
Shenzhen University

Large user differences and low standardization are the main challenges faced by medical ultrasound diagnosis. Based on technologies of image analysis, artificial intelligence and robotics, Shenzhen University's MUSIC (Medical UltraSound Image Computing, www.music-bme.net) laboratory has long been committed to the standardization, quantification and intelligent research of ultrasound diagnosis. This talk will introduce in detail the series of researches carried out by the MUSIC laboratory based on reinforcement learning, such as standard plane localization in 3D ultrasound, multi-modal ultrasound image analysis and landmark localization, and reveal the research ideas of using cutting-edge artificial intelligence methods to solve the challenges faced by ultrasound diagnosis.

弱监督和无监督学习在医学及病理图像分析上的探索

许　燕
北京航空航天大学
Email: xuyan@buaa.edu.cn

医学图像配准在临床医学和研究中都有着十分重要的应用，但是由于医学图像的空间结构复杂，图像的信息量较大，给算法的配准带来了一定的困难。虽然目前已经出现了多种可以用于医学图像配准的算法，但是这些算法在细微的组织结构的配准中表现并不理想。我们提出一种弱监督或无监督深度学习的可形变医学图像配准算法，能够同时提取图像的特征并生成光流场，可用于配准细微的组织结构。在 3D 的医学图像和 2D 的病理图像上都获得了很好的准确率。

Weakly Supervised and Unsupervised Learning for Medical Image Analysis

Yan Xu, Beihang University

3D medical image registration is of great clinical importance. However, supervised learning methods require a large amount of accurately annotated corresponding control points (or morphing), which are very difficult to obtain. Unsupervised learning methods ease the burden of manual annotation by exploiting unlabeled data without supervision. In this article, we propose a new unsupervised learning method using convolutional neural networks under an end-to-end framework, Volume Tweening Network (VTN), for 3D medical image registration. We propose three innovative technical components: (1) An end-to-end cascading scheme that resolves large displacement; (2) An efficient integration of affine registration network; and (3) An additional invertibility loss that encourages backward consistency. Experiments demonstrate that our algorithm is 880x faster (or 3.3x faster without GPU acceleration) than traditional optimization-based methods and achieves state-of-the-art performance in medical image registration.

基于“What”和“Where”的视觉神经信息编码方法

何晖光
中国科学院自动化研究所
Email: huiguang.he@ia.ac.cn

视觉信息编解码是通过计算方法建立从视觉系统与外界视觉刺激信息之间的映射模型，探索大脑视觉信息处理的过程和机理，其研究不仅有助于探索视觉的加工机制，而且可促进计算机视觉的类脑研究。过去的基于 fMRI 的神经编码模型要么依赖于对感受野空间特性的强先验假设，要么依赖于要人工设置的参数估计方法，这极大地限制了它们的编码能力。为了解决这两个问题，我们提出了一个新的“what”和“where”神经编码框架，将深度神经网络分成特征维度（“what”）与空间维度（“where”）进行学习。在空间维度，我们采用了稀疏和平滑的感受野进行编码。在特征维度，编码的神经网络特征图被同时回归到体素响应。我们将这两个维度的学习统一到端到端的深度框架下，在公开的 fMRI 数据集上的实验表明该方法比现有的几种方法具有更好的编码性能。

Neural Encoding for Human Visual Cortex with Deep Neural Networks Learning “What” and “Where”

Huiguang He
Institute of Automation, Chinese Academy of Sciences

Neural encoding, a crucial aspect to understand human brain information processing system, aims to establish a quantitative relationship between the stimuli and the evoked brain activities. In the field of visual neuroscience, with the ability to explain how neurons in primary visual cortex work, population receptive field (pRF) models have enjoyed high popularity and made reliable progress in recent years. However, existing models rely on either the inflexible prior assumptions about pRF or the clumsy parameter estimation methods, severely limiting the expressiveness and interpretability. We propose a novel neural encoding framework by learning “what” and “where” with deep neural networks. It involves two separate aspects: the spatial characteristic (“where”) and feature selection (“what”) of neuron populations in visual cortex. Specifically, our approach first encodes visual stimuli into hierarchically intermediate features through a pretrained deep neural network (DNN), then converts DNN features into refined features with the channel attention and spatial receptive field to learn “where”, and finally regresses refined features simultaneously onto voxel activities to learn “what”. The sparsity regularization and smoothness regularization are adopted in our modeling approach, so that the crucial receptive field can be estimated automatically without prior assumptions about shapes. Furthermore, an attempt is made to extend the voxel-wise modeling approach to multi-voxel joint encoding models, and we show that it is conducive to rescuing voxels with poor signal-to-noise characteristics. Extensive empirical results demonstrate that the method developed herein provides an effective strategy to establish neural encoding for human visual cortex, with the weaker prior constraints but the higher encoding performance.

CEST-MRI 的 Z 谱再挖掘：从线型拟合到多参数方法

宋小磊
清华大学
Email: songxl@tsinghua.edu.cn

化学交换饱和转移磁共振成像（Chemical Exchange Saturation Transfer Magnetic Resonance Imaging，CEST-MRI）可以通过水信号的减少来间接实现对特定分子的灵敏检测，成为近年备受关注的一种分子影像技术。类似于核磁谱（MRS），通常将水信号随饱和脉冲频率变化的谱线即 Z 谱来作为 CEST 的谱特征。针对活体成像面临的信号弱，干扰多（如直接水饱和（Direct water Saturation, DS）和磁化转移对比（Magnetization Transfer Contrast, MTC）等），以及对 B0、B1 匀场的敏感性等挑战，本文将通过 Z 谱数据再挖掘来提升 CEST 成像性能和损伤检测的灵敏度和特异性，主要包括：1）不同段 Z 谱的多层次 Histogram 分布分析来确定ＣＥＳＴ信号源；２）用洛伦兹和高斯混合线性进行Ｚ谱拟合并加入Ｂ１先验；３）利用多饱和参数调制进行有效ＣＥＳＴ图像提取；方法均在高场小动物模型实验中验证，将进一步进行临床仪器的转换和推广。

Dig More from CEST Zspectra, from Lineshape Fitting to Multiparametric Methods

Xiaolei Song
Tsinghua University

Chemical exchange saturation transfer（CEST）MRI is becoming an attractive molecular imaging technique, owing to its capability of sensitive detection for certain molecules. CEST profile is usually characterized by Z-spectrum, which sweeps the saturation frequency and plots the water signal change, with CEST signal indirectly presented via the frequency-specific reduction of water signal. However, in vivo CEST imaging faces many challenges, including weak signal, interference from direct water saturation and magnetization transfer, and high requirement to field homogeneity. To achieve better CEST performance and more specific lesion characterization, we developed methods to dig more from Z-spectrum. Briefly, we developed a histogram-based distribution analysis for Z-spectral different frequency range, to compare the brain region of normal and disease group; We also used a lineshape combining Gaussian and Lorentzian for fitting the reference signal with integration of B1-dependence off-line simulation; We also utilized varied saturation length or power to more effectively extract CEST signal. These methods have been validated using rodent models at high-field MRI, we plan to translate them further into clinical situation.

基于高阶脑网络建模和机器学习的脑疾病个体化诊断研究

张　寒
张江实验室脑与智能科技研究院
Email: hanzhang.bit@gmail.com

理解大脑功能网络及其正常和异常发育老化对脑疾病研究至关重要。针对个体化诊断这一临床应用需求，需要对脑功能网络从时间和空间以及因果关系角度进行深入建模，提取敏感的网络特征，提高疾病分类正确率。我将报告我的课题组最近几年提出的新的脑网络建模和基于脑网络的机器学习研究，其中包括动态脑网络建模、高阶脑网络分析及基于脑网络的疾病分类软件包、介观和宏观多尺度动态因果建模、多层网络分析、脑网络冗余性分析、基于功能磁共振的深度学习等新方法以及它们在脑疾病如老年痴呆症早期检测中的应用。

Machine Learning on High-order Brain Functional Networks for Individualized Disease Diagnosis

Han Zhang
Institute of Brain-Intelligence Technology, ZHANGJIANG LAB

Understanding brain functional network during development and aging is important for brain disease studies. Advanced brain network modeling by disentangling its spatial and temporal patterns and the causal interactions inside of it can be of great help in increasing sensitivity of disease detection. I will introduce our recent works on novel brain network modeling methods and network-based machine learning studies, including dynamic brain functional network modeling, high-order brain network, toolbox for brain network construction and network-based classification, multiscale dynamic causal modeling, multilayer network analysis, dynamic network redundancy analysis, and fMRI-based deep learning for early Alzheimer's disease detection.

深度学习多对比度快速磁共振成像与分析

王珊珊
中国科学院深圳先进技术研究院
Email: ss.wang@siat.ac.cn

磁共振是一种重要的医学成像工具，它可通过不同序列获得丰富的对比度信息，如 T1,T2, DWI 等。在实际临床应用中，医生需要结合多种对比度的图像进行疾病诊断或疗效评估，然而获取多对比度图像的时间往往较长，且对多对比度图像的分析和诊断高度依赖人工。针对这两项挑战，我们研发了深度学习多对比度快速成像方法，并且进行多模态的无监督配准学习以及自动高精度的病变分割，并尝试了结合多模态的人工智能组学分类。这些创新技术包括复数卷积网络、对偶一致性约束、维度融合分割框架和跨层特征融合策略，为磁共振医学影像的发展提供新的思路。

Fast Multi-contrast MR Imaging and Analysis with Deep Learning

Shanshan Wang
Shenzhen Institutes of Advanced Technologies, Chinese Academy of Sciences

MRI is an important imaging modality, which can provide versatile information such as T1, T2, DWI images for both research and clinical applications. Radiologists usually simultaneously utilize these multi-contrast images for disease diagnosis and treatment planning. However, the imaging time for multi-contrast MRI is very long and its analysis is very troublesome and highly dependent on radiologists. To address these two challenges, we have developed a series of deep learning methods for fast multi-contrast MR imaging and efficient analysis. We innovatively developed methods like Deepcomplex MRI for MR reconstruction from undersampled k-space data, unsupervised learning frameworks for MR image registration and automatic segmentation and classification, which are expected to pave new ways for exploring prior knowledges for the development of MRI.

无 CT 辐射伴随的 PET 延迟成像

朱闻韬
之江实验室
Email: wentao.zhu@zhejianglab.com

临床 PET 成像通常由同步扫描且严格配准的 CT 获取衰减校正信息。延迟 PET 成像时人体躺位较第一次扫描有所变化，因此通常需要对成像部位再次进行 CT 扫描。我们设计了一种用于无需再次 CT 扫描的延迟 PET 成像方法。该方法的核心为两个联动的神经网络：伪 PET 图像重建网络和延迟 CT 生成网络。伪 PET 图像重建网络旨在将原始 PET 数据转换成边界清晰、结构完整的伪 PET 图像，从而解决 CT 信息缺失时现有 PET 图像恢复方法的图像质量差，难以应用于配准的问题。CT 图像生成网络则通过寻找首次扫描和延迟扫描 PET/CT 图像间的映射关系来生成延迟 CT 图像，该网络的目标函数由图像相似性度量项和约束变形场的正则化项构成。实验结果表明，该方法生成的延迟 CT 图像可获取高质量、定量精确的 PET 延迟图像。

CT-less PET Delayed Imaging

Wentao Zhu
Zhejiang Lab

In clinical PET imaging, the attenuation correction is usually obtained by co-registered CT. As the body in the delayed scan usually deforms from the first scan, an additional CT scan is usually required for the body parts in the delayed scan. We propose a novel delayed PET imaging method that requires no additional CT scans, which joints two key neural networks: the pseudo PET recon network, and the delayed CT generation network. The first network aims at translating raw PET data to pseudo PET image with clear boundary and detailed structures, so as to improve the image quality of routine PET reconstruction method when the attenuation information is missing. The delayed CT generation network is used to generate the delayed CT image through mapping PET/CT images from the first scan to the delayed scan. The loss function combines an image similarity term and a regularization term based on the deformation field. Results show that the proposed method generates PET images with high quality and quantitative accuracy.

基于深度语义分割特征的影像组学方法

黄炳升
深圳大学
Email: huangb@szu.edu.cn

近年来，影像组学和深度学习（DL）结合的方法在一些医学图像分类任务中表现优秀，但大部分 DL 分类网络在小病灶任务上难以捕捉到有效特征，容易过拟合；且大多缺乏有效的特征选择方法。我们提出一种基于深度语义分割特征的影像组学框架（DSFR），从分割模型提取病灶的深层分割特征，随后基于特征相似性适应算法选择包含较多病灶信息的特征集，并输入机器学习分类器完成分类。我们在深静脉血栓的溶栓疗效预测和胰腺神经内分泌肿瘤的病理分级预测任务上验证了所提出的方法的性能优于传统影像组学方法或 DL 结合影像组学的方法。我们进一步利用主成分分析进行特征降维并可视化，结果显示 DSFR 方法的特征的区分能力更强。同时，特征可视化显示，基于 DSFR 获取的独立验证集的特征分布与训练集的分布更趋于一致，从而体现出更好的泛化性。

A Novel Radiomics Approach Based on Deep Semantic Segmentation Features

Bingsheng Huang
Shenzhen University

In recent years, the combination of imaging and deep learning (DL) has performed well in some medical image classification tasks, but most DL classification networks are difficult to capture effective features on small lesion tasks and easily face the challenge of overfitting; and most of these combinations lack effective feature selection methods. We propose a deep semantic segmentation feature-based radiomics (DSFR) framework to extract deep segmentation features of lesions from the segmentation network, and then select the feature combination containing more lesion information based on feature similarity adaptation algorithm, and finally input the feature sets into a machine learning classifier for classification. We test the validity of the proposed method on thrombolytic efficacy prediction in deep vein thrombosis and pathological grade prediction tasks in pancreatic neuroendocrine tumors, showing superior performance to the state-of-the-art deep learning radiomics methods. We use principal component analysis for feature dimensionality reduction and visualization, and the results show that the DSFR features have better differentiation ability compared with other methods. Further, we show that the feature distribution of the independent validation set extracted by DSFR tends to be consistent with the training set, thus providing better generalization ability.